The invention has been described using embodiments of the invention. It is to be understood, however, that other expedients known to those skilled in the art or disclosed herein may be employed without departing from the scope of the appended claims.

Claims

1. A method of operating a surveying instrument (10) placed in a orthogonal XYZ-system at (0,0,0) having a movable unit (20), said instrument defining a sight line (128) that is controllably rotatable around a first axis (50), essentially horizontal, and around a second axis (90), essentially vertical, wherein said second axis (90) may be inaccurately positioned so that it deviates from a true vertical axis, and said first axis (50) may deviate from being orthogonal to the second axis (90); the method comprising the steps of determining at least one of the following group of errors relating to the instrument and/or its location:

a) a trunnion axis error T as a function of the deviation from 90 degrees between the first axis (50) and the second axis;

b) a horizontal collimation error C_H, being the deviation between the sight line (128) and the perpendicular angle as related to the first axis (50); and

c) a total plumb error defined by components, P_I and P_{II}, being two separate angular values defining the tilt of the instrument as related to the plumb line through the same; and

d) using these determined values in continuously controlling the alignment when aiming the instrument.

2. A method of operating a surveying instrument according to claim 1, wherein the adjustment is performed using a controller comprising a microprocessor for controlling the alignment of the instrument.

3. A method of operating a surveying instrument according to claim 2, wherein said controller is adapted to automatically compensate for determined errors while following an arbitrary straight line between two points using the following steps: define two points A and B on a plane; calculate an angle Θ, a height Z_0, and an angle H_0, where Θ being the vertical angle between a projection of said arbitrary line in the YZ-plane through the instrument 710 (0,0,0) and the Z-axis, the height Z_0 being the height where said projection crosses the Z-axis, and the angle H_0, being the angle in the XY-plane between the Y-axis and a line perpendicular to the projection of the

line between A and B, and using these values to control the movement of the instrument.

4. A method of operating a surveying instrument according to claim 3, wherein when aiming in an arbitrary horizontal angle H the corresponding vertical angle V to a point on the line A - B is calculated from Z_0, H_0 and Θ, this value V is then used as a reference input to the vertical servomotor, resulting in that the vertical aiming is so controlled that the instrument will follow a straight line between said two points when manipulating a knob for horizontal aiming.

5. A method of operating a surveying instrument according to claim 3, wherein when aiming in an arbitrary vertical angle V the corresponding horizontal angle H to a point on the line A - B, where H is calculated from Z_0, H_0 and Θ, this value H is the used as an input as reference input to the horizontal servomotor, resulting in the instrument to follow a straight line between said two points when manipulating a knob for vertical aiming.

6. A method of operating a surveying instrument according to claim 2, wherein said controller is adapted to automatically compensate for determined errors while following a horizontal straight line on a plane using the following steps:
define the plane orientation by measuring the position of at least two points on the plane;
input the desired height value h;
calculate the perpendicular angle H_0 to the projection of the desired horizontal line in the XY-plane; for any horizontal angle H, calculate the corresponding vertical angle V, and use this value to control the vertical servo.

7. A method of operating a surveying instrument according to claim 2 wherein the aiming of the movable unit (20) may be effected using a vertical and a horizontal servomotor and where the horizontal servomotor is controlled to compensate for said

errors, resulting in that when a knob for vertical aiming is manipulated, the aiming will follow a plump line.

8. A method of operating a surveying instrument (10), said instrument having a movable unit (20) that is controllably rotatable around a first axis (50) and around a second axis (90), wherein said second axis (90) may be inaccurately positioned so that it deviates from a true vertical axis, and said first axis (50) may deviate from being orthogonal to the second axis (90); the method comprising the steps of:

a) setting a horizontal reference value (R_H) indicative of a desired horizontal orientation of said movable unit (20);

b) detecting a horizontal orientation value (Hs) indicative of a current rotational orientation around said second axis (90);

c) receiving a horizontal orientation correction value (H_{EC}) indicative of a horizontal orientation deviation of said movable unit (20); wherein said horizontal orientation correction value (H_{EC}) is generated in dependence of a transverse plumb error value (P_I; P'_I); said transverse plumb error value (P_I; P'_I) being dependent on said horizontal orientation of said movable unit (20); and

wherein said received horizontal orientation correction value (H_{EC}) is dependent on the vertical orientation (V) of the movable unit (20) so as to compensate for horizontal orientation deviations that may occur as a consequence of pivoting around said first axis (50);

d) generating a horizontal position value (H) indicative of a current horizontal orientation of said movable unit (20) in response to said detected horizontal orientation value (Hs) and said horizontal orientation correction value (H_{EC});

e) generating a horizontal error value (e_H) in dependence on said horizontal position value (H) and said horizontal reference value (R_H);

f) automatically controlling the horizontal orientation of the movable unit (20) in dependence of said horizontal error value (e_H).

9. The method according to claim 8, further comprising

g) repeating steps b) to f) of claim 8 until said horizontal error value (e_H) is smaller than a predetermined threshold value (D_F).

10. The method according to claim 8 or 9, wherein

said horizontal orientation correction value (H_{EC}) is dependent on a predicted transverse plumb error value (P'_I); and wherein

the predicted transverse plumb error value (P'_I) is generated in dependence on said detected horizontal orientation value (Hs).

11. The method according to claim 8 or 9, wherein

said horizontal orientation correction value (H_{EC}) is generated in response a measured transverse plumb error value (P_I); said measured transverse plumb error value (P_I) being inherently dependent on the horizontal position of the movable unit (20) when the transverse plumb error (P_I) deviates from zero.

12. The method according to any one of claims 8,9,10 or 11 wherein

steps b), d), e) and f) of claim 8 are performed with a first repetition frequency; and wherein

said horizontal orientation correction value (H_{EC}) is updated with a second repetition frequency; said second repetition frequency being lower than said first repetition frequency.

13. The method according to claim 12 when dependent on claim 9, 10 or 11, wherein

said transverse plumb error value is updated with said second repetition frequency.

14. The method according to any one of claims 8 - 13, wherein

said predetermined threshold value (D_F) is less than ten arcseconds.

15. The method according to any one of claims 8 - 13, wherein

said predetermined threshold value (D_F) is less than one arcsecond.

16. The method according to any one of claims 8 - 15, further comprising the step of: pivoting said movable unit (20) around said first axis (50) so as to change a vertical orientation (V) of said movable unit (20).

17. The method according to any one of claims 8 - 16, wherein: said vertical orientation (V) of the movable unit (20) is generated in dependence of a longitudinal plumb error value (P_{II}; P'_{II}); said longitudinal plumb error value (P_{II}; P'_{II}) being dependent on said horizontal orientation of said movable unit (20).

18. A method of operating a surveying instrument (10) having a movable unit (20) that is controllably rotatable around a first axis (50) and around a second axis (90), wherein said second axis (90) may be inaccurately positioned so that it deviates from a true vertical axis, and said first axis (50) may deviate from being orthogonal to the second axis (90); the method comprising the steps of:

setting a desired first horizontal orientation of said movable unit (20) so that a horizontal component of the aim of a sight line (128) of said surveying instrument (10) is directed in a first compass bearing;

pivoting said movable unit (20) around said first axis (50) so as to change a vertical orientation (V) of said movable unit (20) until said horizontal component of the aim of said sight line (128) of said surveying instrument (10) is directed in a second compass bearing; said second compass bearing deviating from said first compass bearing;

generating a horizontal position value (H) indicative of a current horizontal orientation of said movable unit (20) in response to a horizontal orientation correction value (H_{EC}); said horizontal orientation correction value (H_{EC}) being dependent on the vertical orientation (V) of the movable unit (20) so as to compensate for horizontal orientation deviations that may occur as a consequence of pivoting around said first axis (50);

automatically controlling a horizontal orientation of the movable unit (20) in dependence of said horizontal position value (H) so that said second compass bearing is opposite said first compass bearing.

19. A method of operating a surveying instrument (10) having a movable unit (20) that is controllably rotatable around a first axis (50) and around a second axis (90), wherein said second axis (90) may be inaccurately positioned so that it deviates from a true vertical axis, and said first axis (50) may deviate from being orthogonal to the second axis (90); the method comprising the steps of:

a) setting a vertical reference value (R_V) indicative of a desired vertical orientation of said movable unit (20);

b) detecting a vertical orientation value (Vs) indicative of a current rotational orientation around said first axis (50);

c) receiving a vertical orientation correction value (V_{EC}; DV) indicative of a vertical orientation deviation of said movable unit (20); wherein

said vertical orientation correction value (V_{EC}; DV) is generated in dependence of a longitudinal plumb error value (P_{II}; P'_{II}); said longitudinal plumb error value (P_{II}; P'_{II}) being dependent on a horizontal orientation of said movable unit (20);

d) generating a vertical position value (V) indicative of a current vertical orientation of said movable unit (20) in response to said detected vertical orientation value (Vs) and said vertical orientation correction value (V_{EC}; DV);

e) generating a vertical error value (e_V) in dependence on said vertical position value (V) and said vertical reference value (R_V);

f) automatically controlling a vertical orientation of the movable unit (20) in dependence of said vertical error value (e_V).

20. The method according to claim 19, further comprising

g) repeating steps b) to f) until said vertical error value (e_V) is smaller than a predetermined threshold value (D_{VF}).

21. The method according to claim 19 or 20, wherein

said vertical orientation correction value (V_{EC}; DV) is dependent on a predicted longitudinal plumb error value (P'_{II}); and wherein

the predicted longitudinal plumb error value (P'_{II}) is generated in dependence on a detected horizontal orientation value (Hs).

22. The method according to claim 19 or 20, wherein

said vertical orientation correction value (V_{EC}; DV) is generated in response a measured longitudinal plumb error value (P_{II}); said measured longitudinal plumb error value (P_{II}) being inherently dependent on the current horizontal position of the movable unit (20).

23. The method according to any one of claims 19 to 22, wherein

steps b), d), e) and f) of claim 19 are performed with a first repetition frequency; and wherein

said vertical orientation correction value (V_{EC}; DV) is updated with a second repetition frequency; said second repetition frequency being lower than said first repetition frequency.

24. The method according to claim 23 when dependent on claim 20, 21 or 22, wherein said plumb error value is updated with said second repetition frequency.

25. The method according to any one of claims 20 - 24, wherein said predetermined threshold value (D_{VF}) is less than ten arcseconds.

26. The method according to any one of claims 20 - 24, wherein said predetermined threshold value (D_{VF}) is less than one arcsecond.

27. The method according to any one of claims 20 - 26, further comprising the step of:

pivoting said movable unit (20) around said second axis (90) so as to change a horizontal orientation of said movable unit (20).

28. A surveying instrument (10) having a movable unit (20) that is controllably rotatable around a first axis (50) and around a second axis (90), wherein said second axis (90) may be inaccurately positioned so that it deviates from a true vertical axis, and said first axis (50) may deviate from being orthogonal to the second axis (90); the surveying instrument further comprising:

means for generating a transverse plumb error value (P_I; P'_I); said transverse plumb error value (P_I; P'_I) being dependent on said horizontal orientation of said movable unit (20);

a horizontal error corrector (412) adapted to generate a horizontal orientation correction value (H_{EC}) in dependence of a vertical position value (V) and said transverse plumb error value (P_I; P'_I); wherein said vertical position value (V) is indicative of a vertical orientation of said movable unit (20); and

a controller (700) having:

a) an input (390) for receiving a horizontal reference value (R_H) indicative of a desired horizontal orientation of said movable unit (20);

b) a sensor for detecting a horizontal orientation value (Hs) indicative of a current rotational orientation around said second axis (90);

c) an input for receiving said horizontal orientation correction value (H_{EC}) indicative of a horizontal orientation deviation of said movable unit (20); and

d) a horizontal position generator (372) adapted to generate a horizontal position value (H) indicative of a current horizontal orientation of said movable unit (20) in response to said detected horizontal orientation value (Hs) and said horizontal orientation correction value (H_{EC}); and

e) means for generating a horizontal error value (e_H) in dependence on said horizontal position value (H) and said horizontal reference value (R_H); wherein

f) said controller is adapted to automatically control the horizontal orientation of the movable unit (20) in dependence of said horizontal error value (e_H).

29. The surveying instrument (10) according to claim 28, wherein said controller is adapted to control the horizontal orientation of the movable unit (20) so that said horizontal error value (e_H) is smaller than a predetermined threshold value (D_F).

30. The surveying instrument (10) according to claim 28 or 29, wherein said controller is adapted to control the orientation of the movable unit (20) such as to compensate for a detected trunnion error.

31. The surveying instrument (10) according to any of claims 28 to 30, wherein said movable unit (20) further comprises optical equipment defining a sight line (128) for allowing said movable unit (20) to be aimed at a target position; wherein said sight line (128) may deviate from being orthogonal to the first axis (50); said deviation constituting a Horizontal Collimation error;

said surveying instrument (10) further comprising a memory (355) for storing an established Horizontal Collimation error value (C_H); and wherein

said horizontal error corrector (412) has an input coupled to receive said established Horizontal Collimation error value (C_H); said horizontal error corrector (412) being adapted to generate said horizontal orientation correction value (H_{EC}) in dependence of said established Horizontal Collimation error value (C_H) so as to obtain compensation for said Horizontal Collimation error.

32. The surveying instrument (10) according to claim 28, 29 or 30, wherein said means for generating a transverse plumb error value (P_I; P'_I) comprises a predictor adapted to generate a predicted transverse plumb error value (P'_I) in dependence on said detected horizontal orientation value (Hs).

33. The surveying instrument (10) according to claim 32, wherein said horizontal error corrector (412) is adapted to generate said horizontal orientation correction value (H_{EC}) in dependence of said predicted transverse plumb error value (P'_I).

34. The surveying instrument (10) according to any one of claims 28 to 33 wherein

said controller (700) is adapted to generate an updated horizontal error value (e_H) with a first repetition frequency; and wherein

said horizontal error corrector (412) is adapted to generate an updated horizontal orientation correction value (H_{EC}) with a second repetition frequency; said second repetition frequency being lower than said first repetition frequency.

35. The surveying instrument (10) according to claim 26 when dependent on claim 28, 29, 30, 31, 32 or 33, wherein

said transverse plumb error value is updated with said second repetition frequency.

36. The surveying instrument (10) according to any one of claims 28 - 35, further comprising:

means for generating a longitudinal plumb error value (P_{II}; P'_{II}); said longitudinal plumb error value (P_{II}; P'_{II}) being dependent on said horizontal orientation of said movable unit (20);

a vertical error corrector (292) adapted to generate a vertical error correction value (V_{EC}) in dependence of said longitudinal plumb error value (P_{II}; P'_{II});

a sensor for detecting a vertical orientation value (Vs) indicative of a current rotational orientation around said first axis (50); and

a vertical position generator (272) adapted to generate said vertical position value (V) of the movable unit (20) in dependence of said vertical error correction value (V_{EC}) and said detected vertical orientation value (Vs); and wherein

said horizontal error corrector (412) is adapted to generate said horizontal orientation correction value (H_{EC}) in dependence of said generated vertical position value (V) and said transverse plumb error value (P_I; P'_I).

37. A surveying instrument (10) having a movable unit (20) that is controllably rotatable around a first axis (50) and around a second axis (90), wherein said second axis (90) may be inaccurately positioned so that it deviates from a true vertical axis, and said first axis (50) may deviate from being orthogonal to the second axis (90); the surveying instrument (10) comprising:

means for generating a longitudinal plumb error value (P_{II}; P'_{II}); said longitudinal plumb error value (P_{II}; P'_{II}) being dependent on said horizontal orientation of said movable unit (20);

a vertical error corrector (292) adapted to generate a vertical error correction value (V_{EC}) in dependence of said longitudinal plumb error value (P_{II}; P'_{II});

a controller (700) having:

a) an input (290) for a vertical reference value (R_V) indicative of a desired vertical orientation of said movable unit (20);

b) a sensor for detecting a vertical orientation value (Vs) indicative of a current rotational orientation around said first axis (50); and

c) an input (273) for receiving a vertical orientation correction value (V_{EC}; DV) indicative of a vertical orientation deviation of said movable unit (20); wherein

said vertical orientation correction value (V_{EC}; DV) is generated in dependence of a longitudinal plumb error value (P_{II}; P'_{II}); said longitudinal plumb error value (P_{II}; P'_{II}) being dependent on said horizontal orientation of said movable unit (20);

d) a vertical position generator (272) adapted to generate a vertical position value (V) of the movable unit (20) in dependence of said vertical error correction value (V_{EC}) and said detected vertical orientation value (Vs);

e) means for generating a vertical error value (e_V) in dependence on said vertical position value (V) and said vertical reference value (R_V); wherein

f) said controller is adapted to automatically control a vertical orientation of the movable unit (20) in dependence of said vertical error value (e_V).

38. The surveying instrument (10) according to claim 37, wherein

said controller is adapted to control the vertical orientation of the movable unit (20) so that said vertical error value (e_V) is smaller than a predetermined threshold value (D_{VF}).

39. The surveying instrument (10) according to claim 37 or 38, wherein

said means for generating a longitudinal plumb error value (P_{II}; P'_{II}) comprises a predictor (226) adapted to generate a predicted longitudinal plumb error value (P'_{II}) in dependence on said detected horizontal orientation value (Hs).

40. An error compensation system for a surveying instrument comprising:

an automatic error measurement system for detecting a tilt error and an error due to mechanical imperfections in said surveying instrument;

a controller adapted to automatically compensate for said detected errors by controlling a servo system of the instrument so as to correct for detected errors when operating said surveying instrument.

41. The error compensation system according to claim 40, wherein said detected errors include a trunnion error (T).

42. The error compensation system according to claim 40, 41, wherein said detected errors include a horizontal collimation error (C_H).

43. The error compensation system according to claim 40, 41 or 42, wherein said controller co-operates with said automatic error measurement system so as to cause a sight line of said surveying instrument to move in a vertical direction in response to

manual control of a vertical direction reference value (R_V) wherein the error from true verticality is less than a predetermined amount.

44. The error compensation system according to claim 40, 41, or 42, wherein said controller co-operates with said automatic error measurement system to cause a point, on a sight line, at an arbitrary fixed distance from said surveying instrument to move in a horizontal direction in response to manual control of a horizontal direction reference value (R_H) wherein the error from true horizontal is less than a predetermined amount.

45. The error compensation system according to any of claims 40 to 44, wherein

said automatic error measurement system comprises a first error correction generator for generating a vertical error correction value (V_{EC}) and a second error correction generator for generating a horizontal error correction value (H_{EC}) dependent on said detected errors; and wherein

said controller is adapted to achieve said error compensation in dependence of said vertical and horizontal error correction values (V_{EC}, H_{EC}).

46. The error compensation system according to claim 45, wherein

said first error correction generator is adapted to generate the vertical error correction value (V_{EC}) in dependence on a longitudinal plumb error value (P_{II}; P'_{II}); and

said second error correction generator is adapted to generate the horizontal error correction value (H_{EC}) in accordance with the following equation:

$$H_{EC} = H_P + C_H/\sin V + (T + P'_I) * \cot V$$

wherein H_P is a constant; T is a detected trunnion axis error; P'_I is a horizontal plumb error value; V is a vertical position value dependent on said vertical error correction value (V_{EC}), and C_H is a horizontal collimation error.

47. The error compensation system according to claim 45 or 46 when dependent on claim 38, wherein

said controller is adapted to generate an updated control signal with a first repetition frequency; and wherein

said automatic error measurement system is adapted to generate said error correction values with a second repetition frequency; said second repetition frequency being lower than said first repetition frequency.

48. The error compensation system according to any of claims 43 or 44, wherein said predetermined amount is less than ten arcseconds.

49. The error compensation system according to any of claims 43 or 44, wherein said predetermined amount is less than one arcsecond .

50. The error compensation system according to any of claims 43 or 44, wherein said predetermined amount is less than one third of an arcsecond.

51. The error compensation system according to any of claims 48 to 50, wherein said controller is adapted to automatically compensate for said detected errors during manual control of said surveying instrument.

52. The error compensation system according to claim 51, wherein said manual control of said surveying instrument includes manual control of a direction reference value.

53. The error compensation system according to any of claims 40 to 50, wherein said controller is adapted to automatically compensate for said detected errors during remote control of said surveying instrument.

54. The error compensation system according to any of claims 40 to 50, wherein said controller is adapted to automatically compensate for said detected errors during automatic control of said surveying instrument.

55. The error compensation system according to any of claims 40 to 54, wherein said controller is adapted to automatically compensate for determined errors while following an arbitrary straight line between two points using the following steps: define two points A and B on a plane; calculate an angle Θ, a height Z_0, and an angle H_0, where Θ being the vertical angle between a projection of said arbitrary line in the YZ-plane through the instrument 710 (0,0,0) and the Z-axis, the height Z_0 being the height where said projection crosses the Z-axis, and the angle H_0, being the angle in the XY-plane between the Y-axis and a line perpendicular to the projection of the line between A and B, and using these values to control the movement of the instrument.

56. The error compensation system according to claim 55, wherein when aiming in an arbitrary horizontal direction H the corresponding vertical angle V to a point on the line A - B is calculated from Z_0, H_0 and Θ, this value V is the used as an input as reference input to the vertical servomotor, allowing a manipulation of a knob for horizontal aiming such that the vertical aiming is controlled such as allowing the instrument to follow a straight line between said two points.

57. The error compensation system according to claim 55, wherein when aiming in an arbitrary vertical direction V the corresponding horizontal angle H to a point on the line A - B, where H is calculated from Z_0, H_0 and Θ, this value H is then used as a reference input to the horizontal servomotor, allowing a manipulation of a knob for vertical aiming such that the horizontal aiming is controlled such as to allow the instrument to follow a straight line between said two points.

58. A surveying instrument including an error compensation system according to any of claims 40 to 54.

Fig. 1

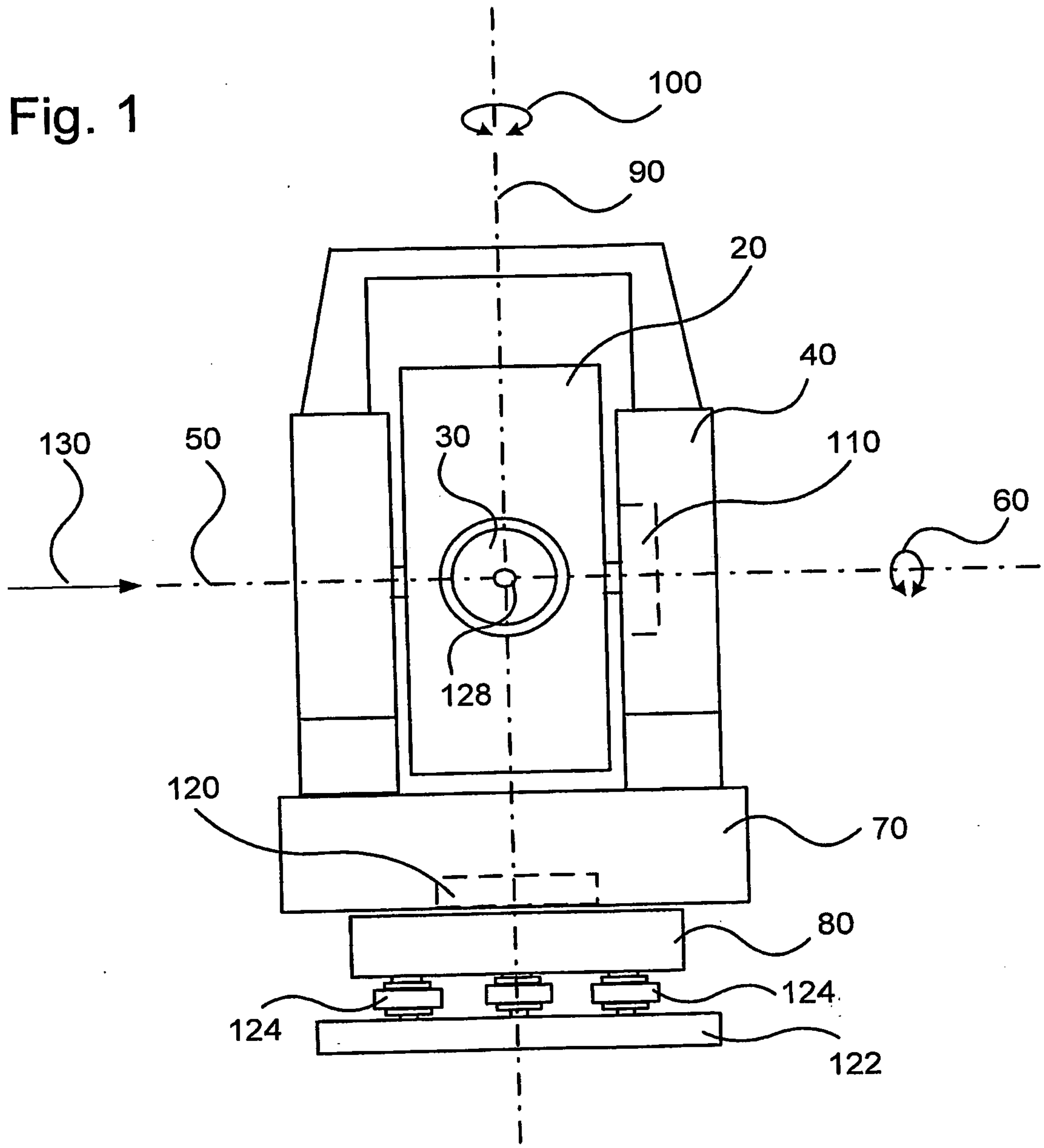


Fig. 2a

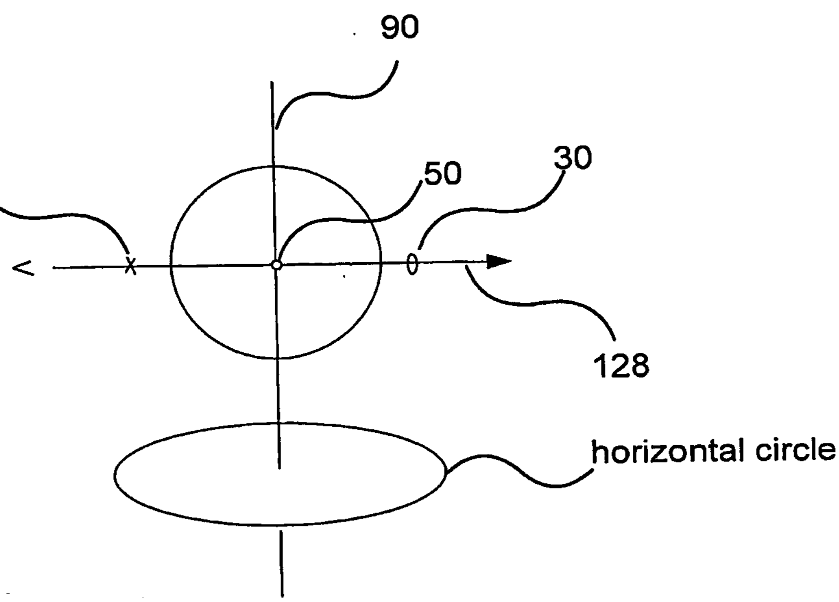

90
32
50
30
128
horizontal circle

Fig. 2b

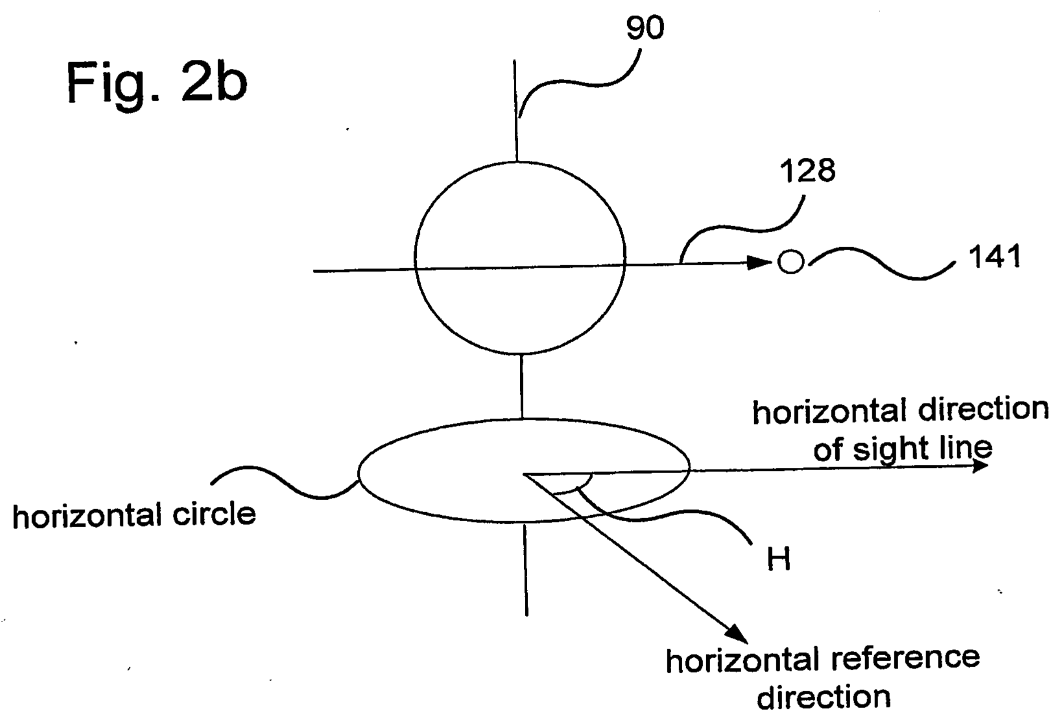

90
128
141
horizontal direction
of sight line
horizontal circle
H
horizontal reference
direction

Fig. 2c

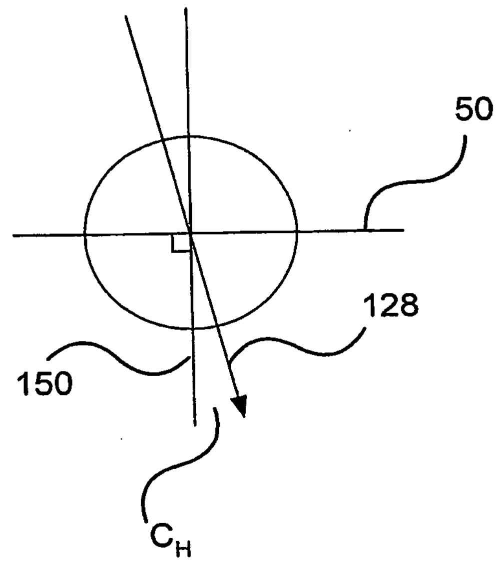


Fig. 2d

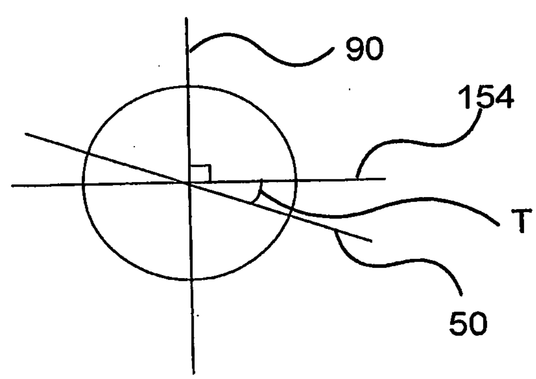


Fig. 2e

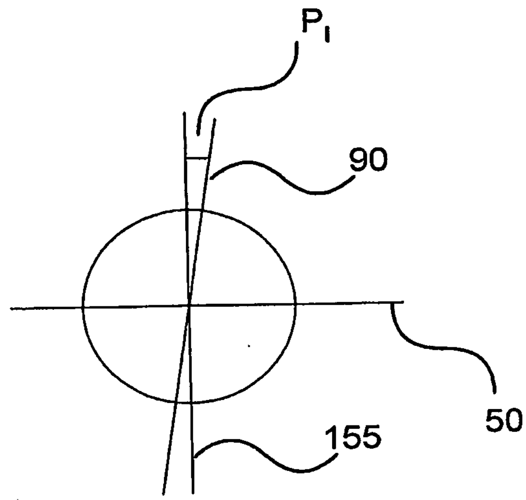
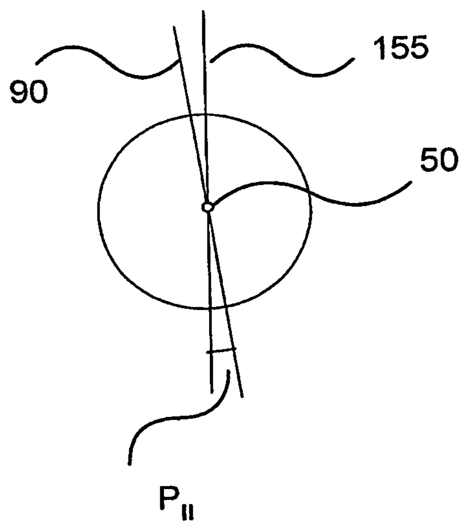
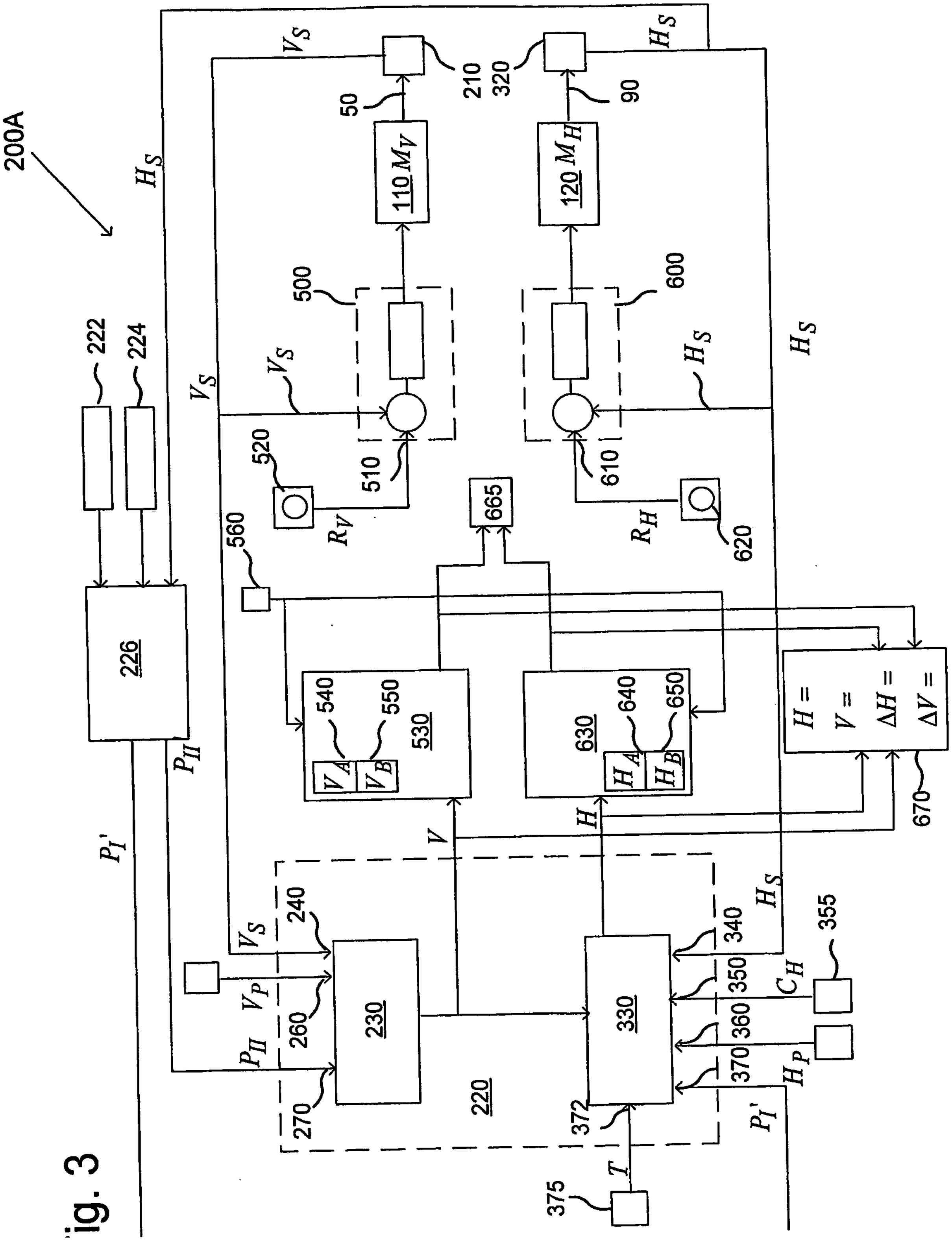


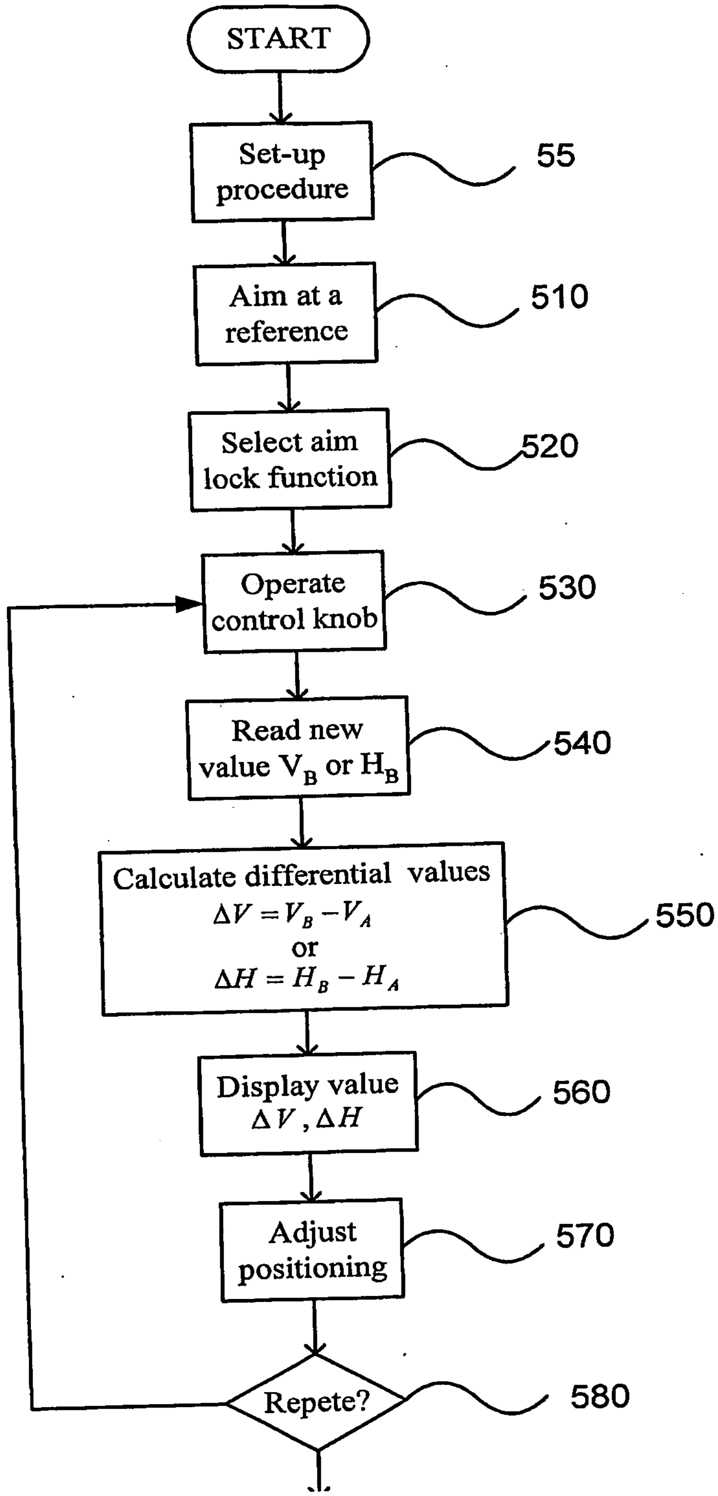
Fig. 2f




200A
226
222
224
230
330
220
530
630
665
670
500
600
110 M_V
120 M_H
$H =$
$V =$
$\Delta H =$
$\Delta V =$

ig. 3

Fig. 4


START
Set-up procedure
55
Aim at a reference
510
Select aim lock function
520
Operate control knob
530
Read new value V_B or H_B
540
Calculate differential values
$\Delta V = V_B - V_A$
or
$\Delta H = H_B - H_A$
550
Display value $\Delta V, \Delta H$
560
Adjust positioning
570
Repete?
580

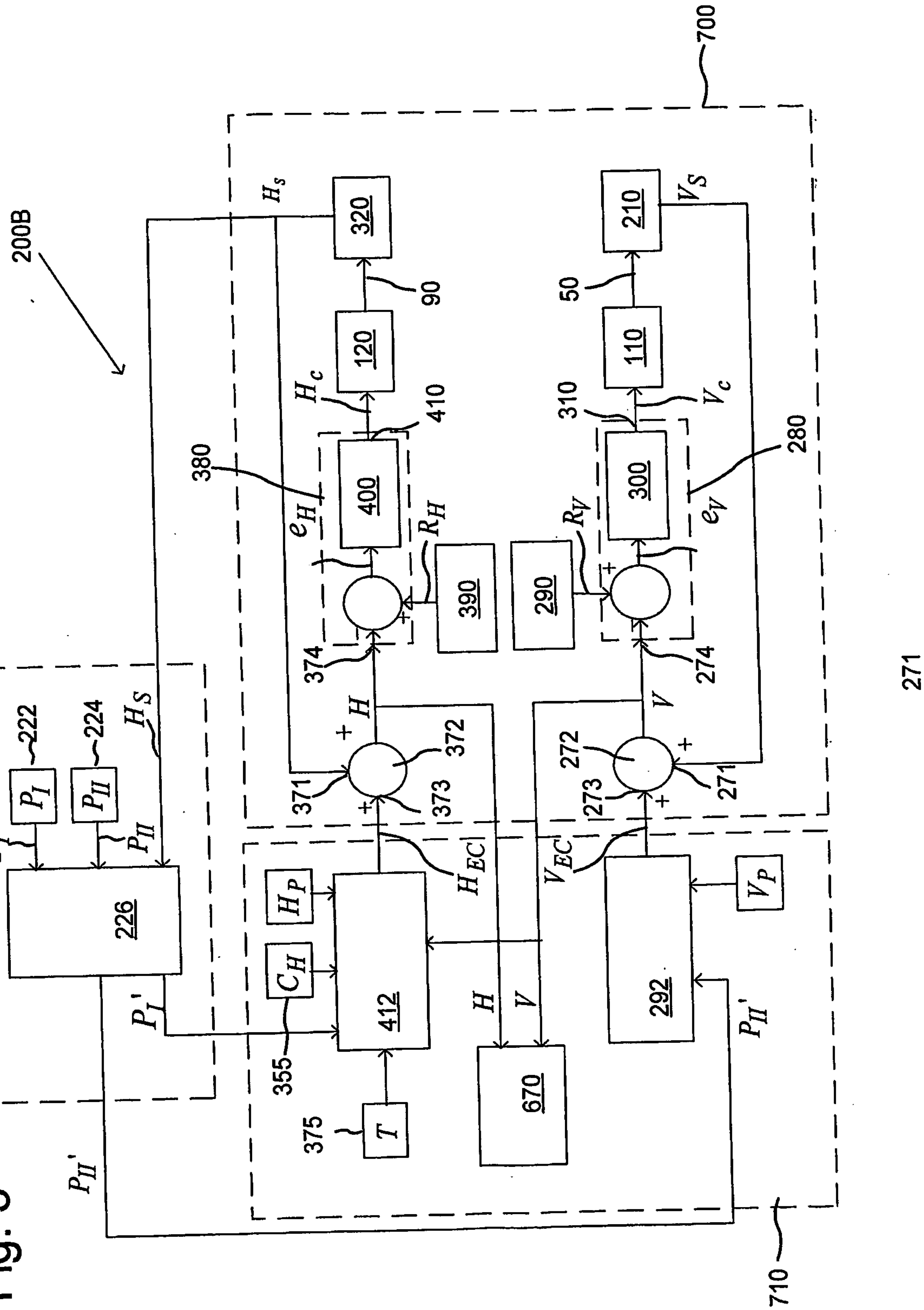

200B
700
710
226
222
224
P_I
P_{II}
H_S
P_I'
P_{II}'
412
292
670
355
375
T
C_H
H_P
V_P
H_{EC}
V_{EC}
H
V
371
372
373
374
271
272
273
274
400
300
390
290
380
280
410
310
e_H
e_V
R_H
R_V
H_c
V_c
120
110
320
210
90
50
H_s
V_S

Fig. 5

Fig. 6

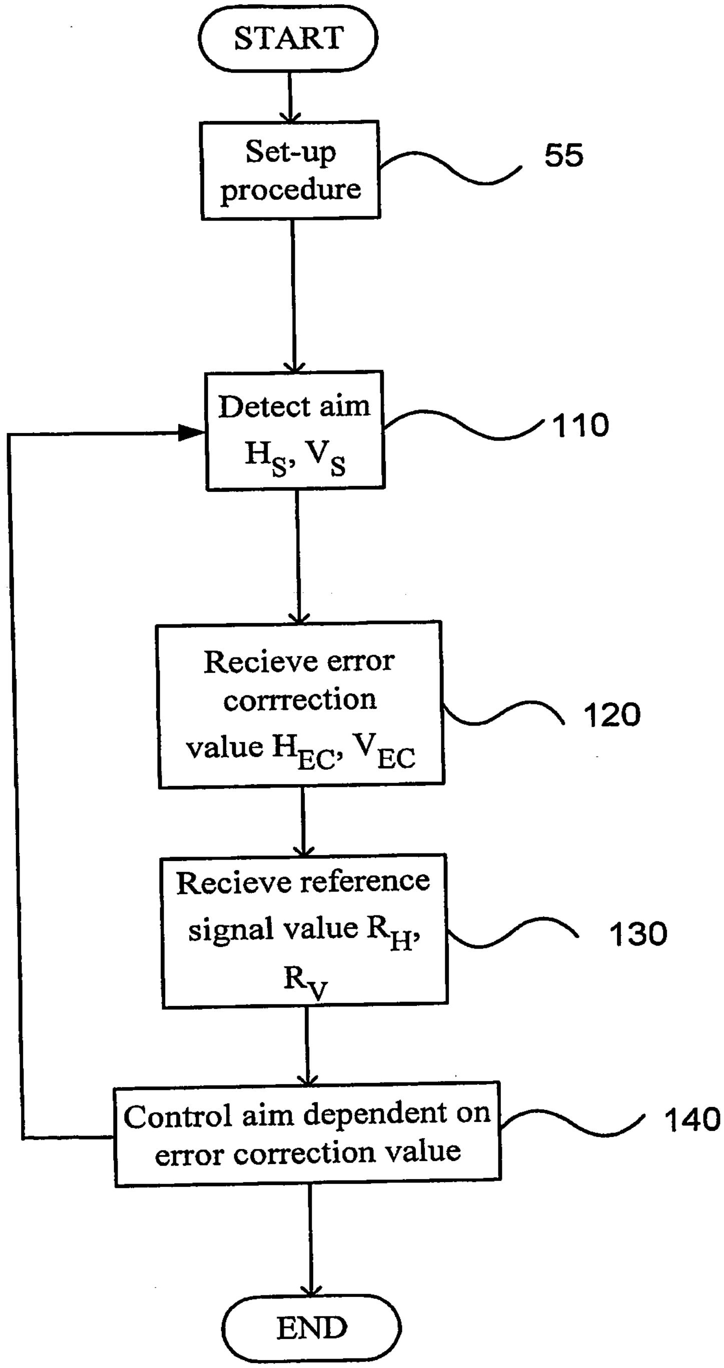

START
Set-up procedure
55
Detect aim H_S, V_S
110
Recieve error corrrection value H_{EC}, V_{EC}
120
Recieve reference signal value R_H, R_V
130
Control aim dependent on error correction value
140
END

Fig. 7

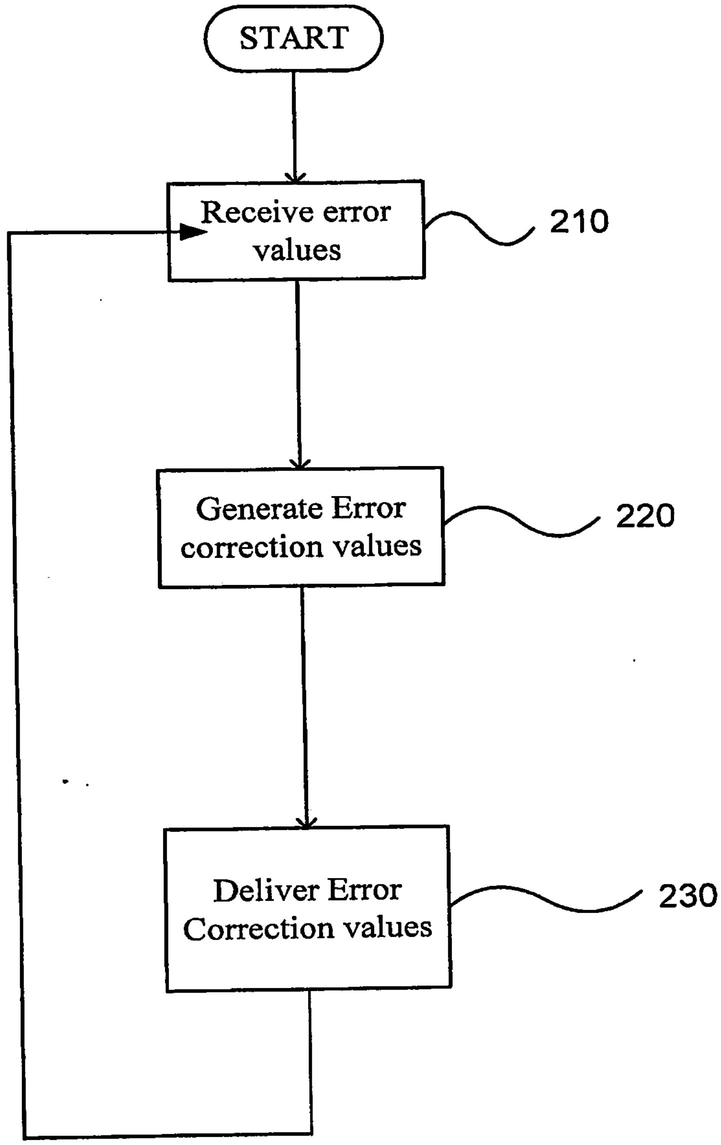

START
Receive error values
210
Generate Error correction values
220
Deliver Error Correction values
230

Fig. 8

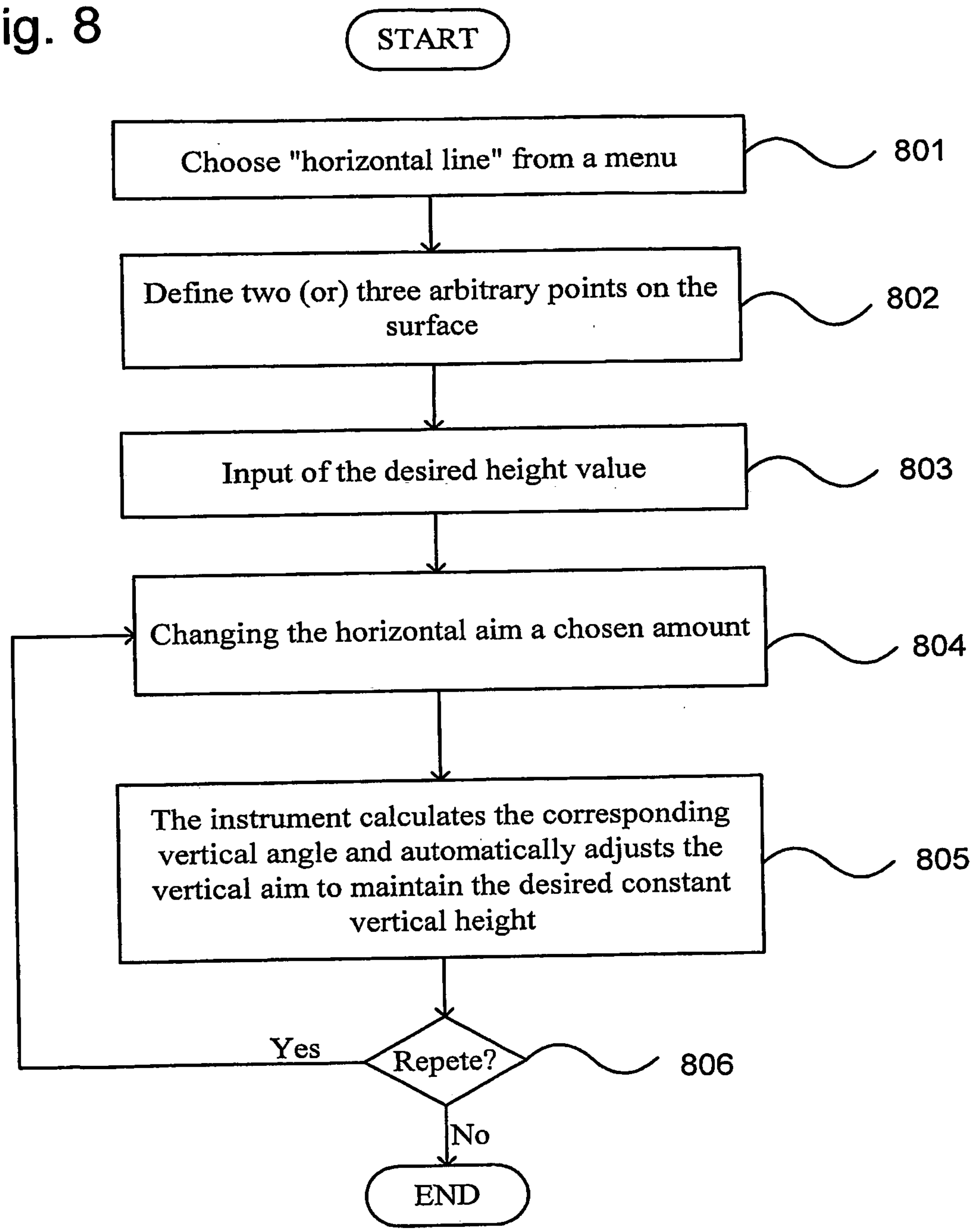

START
Choose "horizontal line" from a menu
801
Define two (or) three arbitrary points on the surface
802
Input of the desired height value
803
Changing the horizontal aim a chosen amount
804
The instrument calculates the corresponding vertical angle and automatically adjusts the vertical aim to maintain the desired constant vertical height
805
Yes
Repete?
806
No
END

Fig. 9

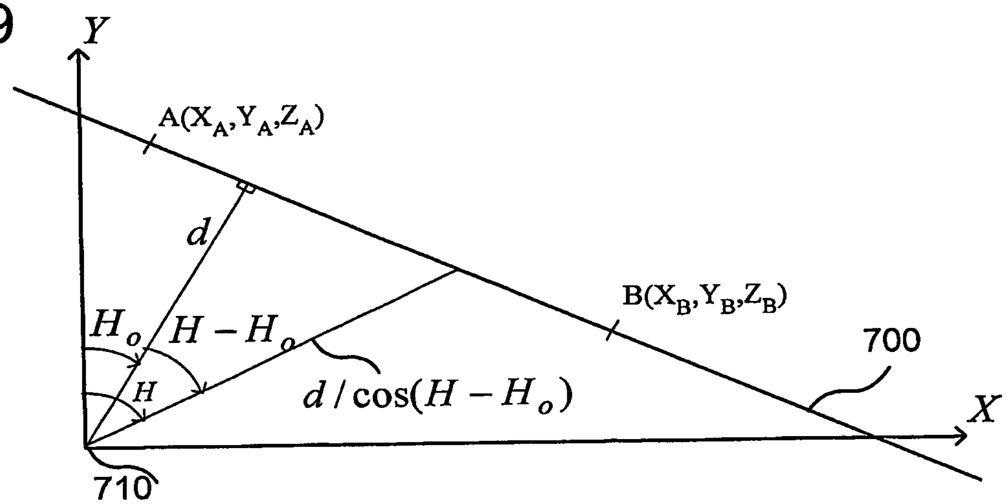


Fig. 10

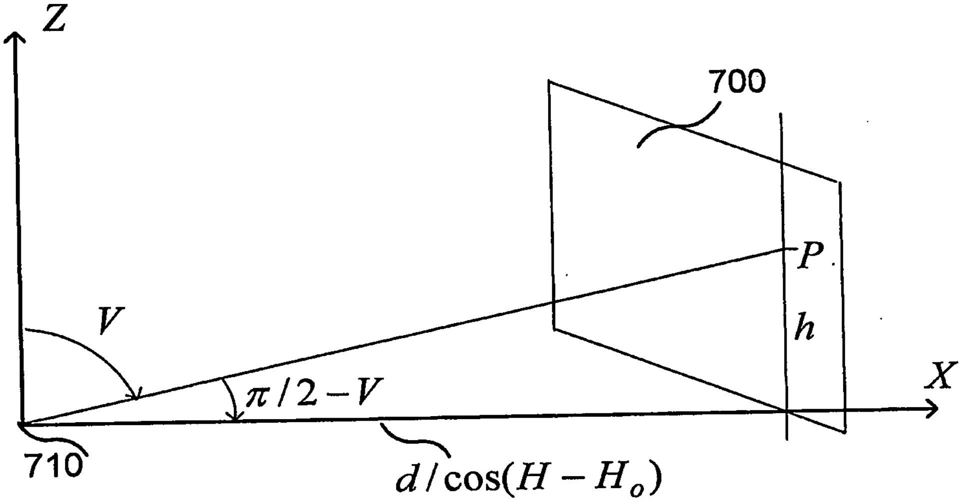


Fig. 11

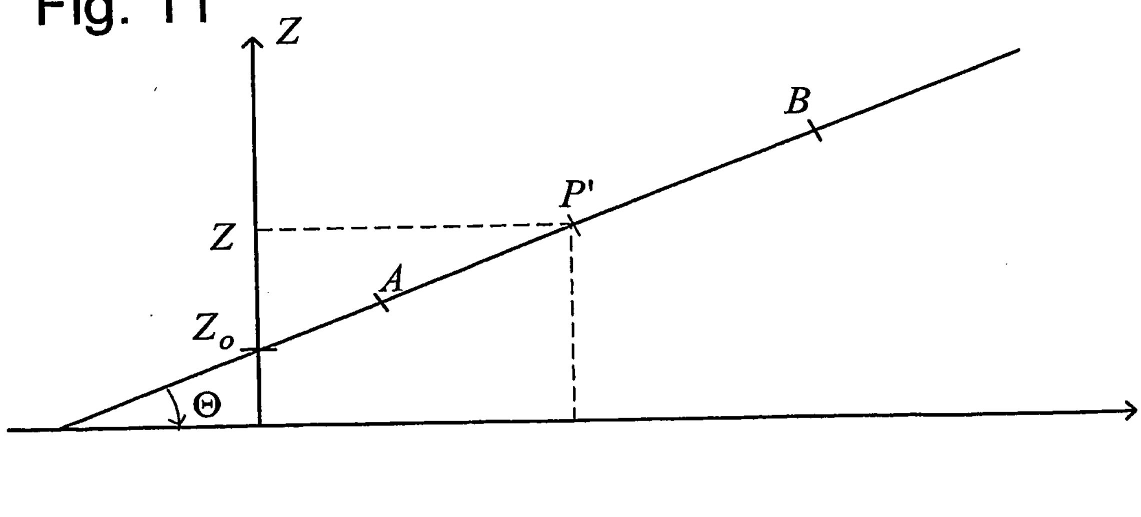
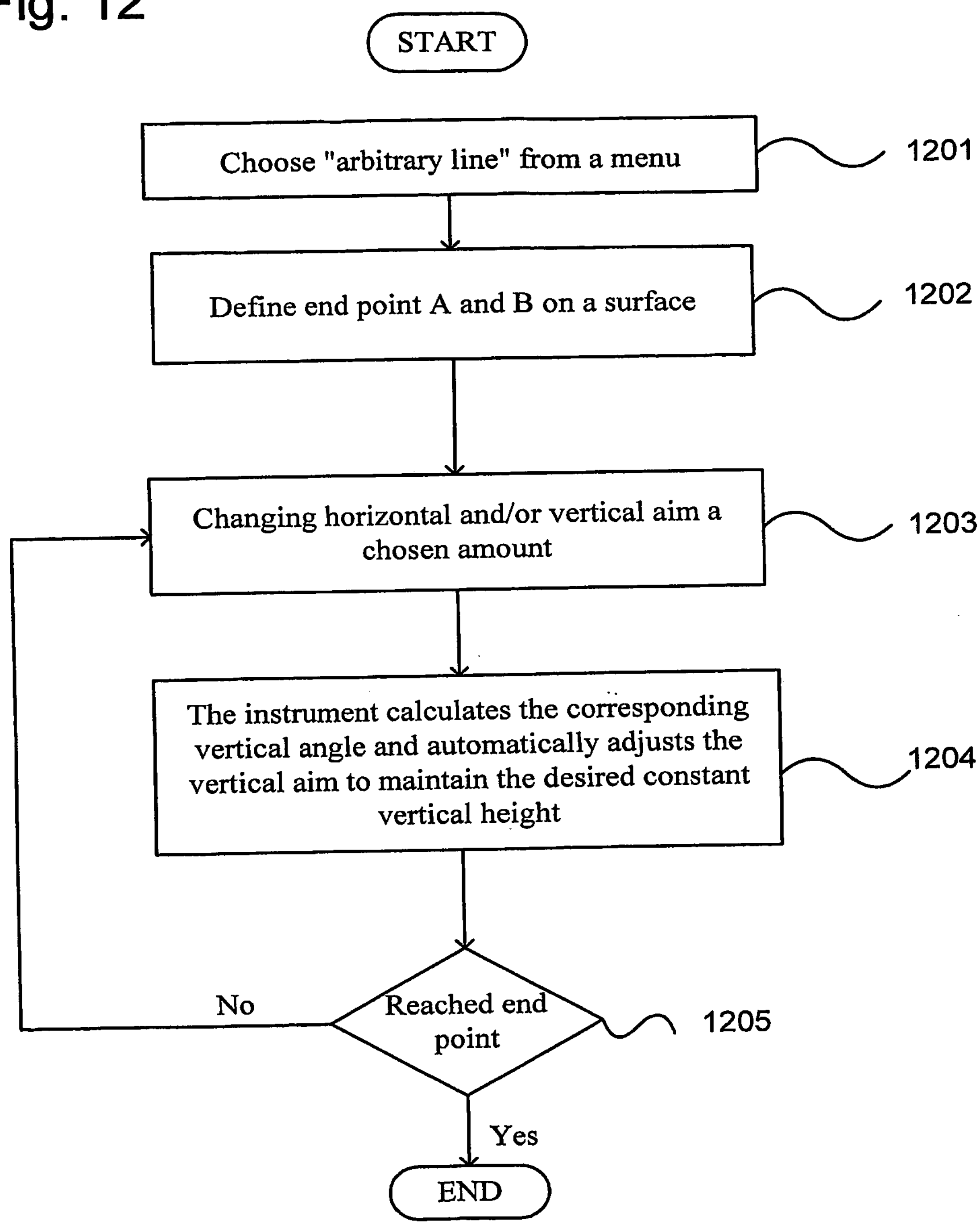


Fig. 12


START
Choose "arbitrary line" from a menu
1201
Define end point A and B on a surface
1202
Changing horizontal and/or vertical aim a chosen amount
1203
The instrument calculates the corresponding vertical angle and automatically adjusts the vertical aim to maintain the desired constant vertical height
1204
Reached end point
1205
No
Yes
END

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 2004/001018

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: G01C 5/02, G01C 15/00
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: G01C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-INTERNAL,WPI,PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 6138367 A (P.RABY), 31 October 2000 (31.10.2000), abstract --	1-58
A	US 6421360 B1 (H.KOUSEK ET AL), 16 July 2002 (16.07.2002), abstract --	1-58
A	DE 10052150 A1 (A.K.KOGYO K.K.), 26 April 2001 (26.04.2001), abstract -- --------	1-58

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
21 Sept 2004	28 -09- 2004

Name and mailing address of the ISA/	Authorized officer
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US	6138367	A	31/10/2000	US	6243658	B	05/06/2001
US	6421360	B1	16/07/2002	CA	2321954	A	29/04/2001
				DE	19952390	A	03/05/2001
				EP	1096224	A	02/05/2001
				JP	2001141459	A	25/05/2001
DE	10052150	A1	26/04/2001	JP	2001124589	A	11/05/2001
				US	6629371	B	07/10/2003